UDC 004:614.84

THE CONCENTRATOR OF THE FIRE EXTINGUISHING SYSTEM

V. Lyashenko, M. Zagirnyak, A. Zinoviev, Y. Soloviev
Kremenchuk Mykhailo Ostrohradskyi National University
vul. Pershotravneva, 20, Kremenchuk, 39600, Ukraine.E-mail: conon-v@ya.ru
Ossokine Guennadi
Firm NEUTRONIC, France. E-mail: ossokine@yandex.ru

A concentrator intended for collect and processing signals of the origin of fire from different sensors and devices is developed. Information from the sensors is transmitted through the system of main and remote concentrators to the fire extinguishing system. The information system is based on the continuous notion of the process of fire occurrence. This system allows one to read the signals from sensors and transmit them to the control panel located at a considerable distance from the seat of fire. Operation of space-time transformation of information (STTI) is defined as an action that combines scanning, measurement, data processing and issuing control signals. CAN interface is created to provide a high level of data protection against damages during operation under difficult conditions.

Key words: information system, concentrator, CAN interface.

КОНЦЕНТРАТОР ІНФОРМАЦІЙНОЇ СИСТЕМИ ПОЖЕЖЕГАСІННЯ

В. П. Ляшенко, М. В. Загірняк, А. С. Зинов'єв, Ю. І. Соловйов
Кременчуцький національний університет імені Михайла Остроградского
вул. Першотравнева, 20, м. Кременчук, 39600, Україна. E-mail: Conon-v@yandex.ru
Ossokine Guennadi
Фірма NEUTRONIC, Франція. E-mail: ossokine@yandex.ru

Розроблено концентратор системи пожежегасіння, що складається з основних і віддалених концентраторів. Запропонована інформаційна система пожежегасіння дозволяє збирати та обробляти сигнали про виникнення пожежі від різноманітних датчиків і пристроїв. В основу інформаційної системи покладені континуальні уявлення про процес виникнення пожежі. Через систему основних і віддалених концентраторів інформація обробляється в інформаційній системі та передається на пульт керування, що розташований на значній відстані від джерела пожежі. Операція просторово-часового перетворення інформації визначена як дія, у якій поєднано сканування вимір та обробка інформації з наступною передачею керуючих сигналів. Для забезпечення високого рівня захисту інформації від ураження під час роботи в складних умовах і сповіщати про пожежу у реальному часі створено CAN інтерфейс.

Ключові слова: інформаційна система, концентратор, CAN-інтерфейс.

PROBLEM STATEMENT. During the recent decades particular attention has been paid to the development of effective systems of human and material values security. It is possible to do it using modern electronic devices. They can be divided into means for digital information processing and means for processing information about physical objects.

When physical phenomena and objects in the sphere of engineering are being studied, the field created by these objects or field that occurs after exposure to the external field are usually studied. Temperature field and the combustion products diffusion during a fire in buildings and structures create these fields. The resulting reflected field is the subject of the analysis. It is subjected to the informational and measuring study and impact.

Means of processing the information about physical objects provide their normal functional state in automatic or semi-automatic mode. Information processing and generating a control action on physical objects are associated with physical problems, as well as with information related to the complexity of the analysis and the formation of the inverse action. We need to simultaneously solve the problems of collecting and processing information about the state of the physical object and the formation of the inverse effect of the physical medium in which the transmitted signal to its media properties affects the signal. It should be noted that, to preserve the information parameters it is necessary to ensure the separation of local information signs and identify their characteristics.

The main attention is paid to the protection of structures against the occurrence of fire and its prevention. With this purpose in view, efficient systems of fire alert, communication of information about it to a considerable distance through the information system have been and are being developed. In addition, the information system generates signals for corresponding sensors within the structure, which allows unattended localization of the fire. Many companies are engaged in development of effective fire-extinguishing systems. Fire extinguishing information system is based on the continual notion of fire occurrence process. It is supposed that a fire appears locally in one or several places and is characterized by smoke content in the room due to the increased concentration of combustion products in the enclosed space. When concentration of combustion products reaches a certain level, corresponding sensors operate and their signals are transmitted to the control panel. Continuous systems (CS) are formed on the basis of continuous media (physical fields), whose properties are determined by the physics of the processes and in general they perform an operation of space-time signal conversion function.

Operation of the space-time transformation of information can be defined as action in which scanning, measurement, information processing and delivery of operating signals are combined.

In accordance with the extension of the range of problems solved by information systems, new methods of converting the signals are developed and investigated. They are based on physical systems with continual and quasi-continual structure that can operate in real-time with both deterministic and random signals. The main sphere of application of such systems includes the solution of complex problems of diagnosis, detection and control.

In this case, the output shows the spatial distribution of the characteristics of the combustion products concentration field.

The objektive of the paper. Development of the concentrator for creation of information fire extinguishing system

EXPERIMENTAL PART AND RESULTS OBTAINED. Development of the sphere of information fire extinguishing systems is based on the use of continual and quasi-continual physical systems of information transformation [1–10]. It is connected with complication of tasks which are set for information systems and transition to adaptive algorithms of management of process of fire extinguishing. From sensors that characterize the state of a physical object in time and space real signals are transmitted. Information about the temporal and spatial state of the object can be read.

Structure of space-time systems, in particular, and sprinkler systems are represented as a set of basic analog integrated cross-coupled devices. This takes into account the physical features of a transformative environment [12]

$$U = \{A, F, X\}, \qquad (1)$$

where U – control field, formed under the influence of a medium in the conversion operator A and having a spatial-temporal dispersion, F – operator of external influence on the environment, X – a signal indicative of the state of the object flowchart.

In most cases, the medium is in the form of a generalized linear operator Fig. 1.

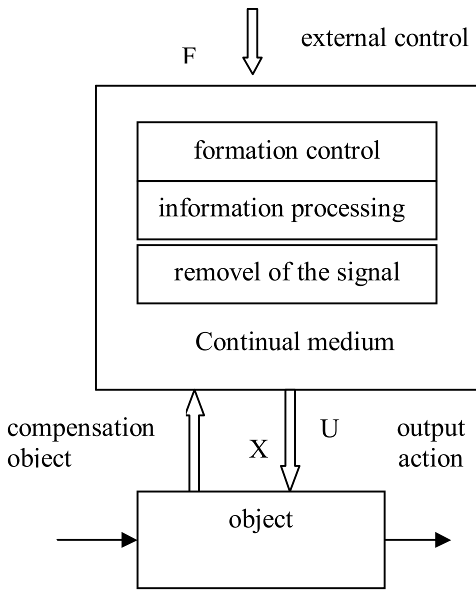

Figure 1 – Model of extinguishing object control

In case of fire in the facility (building or structure) information system analyzes data from the sensors and generates signals of internal and external control firefighting

The operator is provided with the conditions of the possibility of signal transmission and separating one or more features. In this case the functionality that can singe out this feature and measure its characteristics is known.

Generalized discrete operator can be represented as

$$F\left(\vec{p}\right) = \sum_{i=1}^{n} h_i p_i \,,$$

where $\vec{h} = (h_i) - n-$ dimensional vector signs, $\vec{p}$ – vector generic implementation process, p_i – components of the vector $\vec{p}$, components of the vector describing the state of the discrete points in space and time (Fig. 1) [1, 2, 11].

For a continuous process, this operator has the form

$$f(p) = \int p(s) h(s)\, ds,$$

where $p(s)$ –- realization of the process, $h(s)$ – the weight function, s– control parameter.

Here a control U signal can be presented in the form.

$$U_i(k,w) = \sum_{j=1}^{n} A_{i,j}(k,w) X_j(k,w), \qquad (2)$$

where A_{ij} – Fourier's transformation from a matrix kernel of the operator of the operating environment.

Thus we consider that external influence of F is absent, and $X_j(k,\omega)$ and $U_i(k,\omega)$ can be presented in the form of Fourier's multidimensional integrals.

$$x_i(k,w) = \int e^{ikr+iwt} x_i(r,t)\, dr dt, \qquad (3)$$

$$U_i(k,w) = \int e^{ikr+iwt} U_i(r,t)\, dr dt\,. \qquad (4)$$

Then control signal in originals can be written down in the form.

$$U_i(r,t) = \sum_{i=1}^{n} \int_S Q_{ij}(r - r_1, t - t_1) x_j(r_1, t_1)\, dr_1 dt_1, \qquad (5)$$

where S – some area of a space-time continuum.

Matrix A_{ij} for the operating continual environment is to meet the requirements of physical feasibility of fire extinguishing process control.

In this case the class of functions A_{ij} is naturally defined by properties of the environment and algorithms of fire extinguishing system control. Consider the information fire extinguishing system consisting of fire emergence environment considered as continual system, sensors, the reception and control firefighter device (RCFD), information processing computing block and a fire extinguishing system control device.

The electrotechnical part of an automatic fire extinguishing system (AFES) consists of the devices combining the RCFD functions and a fire extinguishing system control device. The RCFD complex is designed for reception of information from fire alert sensors, manual start-up sensors, start-up blocking sensors, transformation and assessment of this information, formation of signals of the notification at emergence of a fire or malfunction, further signaling and delivery of commands for other devices, and also control of installations of powder, aerosol, gas fire extinguishing and systems of smoke removal.

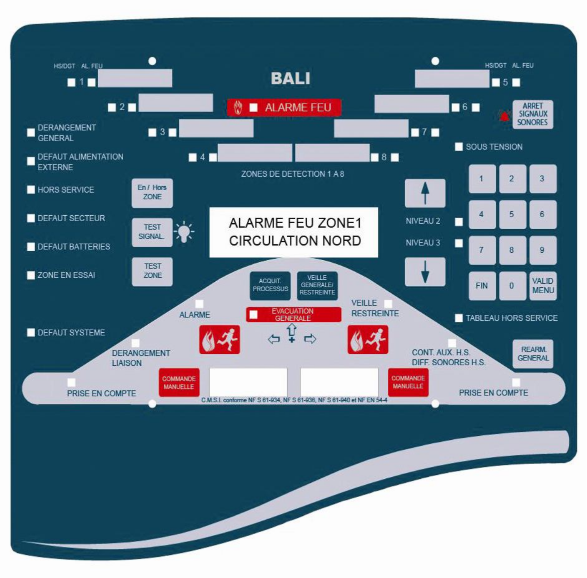

Figure 2 – Concentrator

AFES are subdivided according to extinguishing agent used:

– gas fire extinguishing (argon, nitrogen);
– powder fire extinguishing (powders of a special chemical composition);
– aerosol fire extinguishing systems (are similar to powders, but the size of particles is 10 times less);
– water fire extinguishing (water);
– foamy fire extinguishing and water-foamy fire extinguishing (water with frothers);
– sprayed water systems(SWS).

The concentrator developed by the authors represents a complex of the universal modules designed (Fig. 3) with opportunity to work both independently and in a multilevel expanded fire extinguishing system, the security alarm system or as a part of Smart Home system. The structure of information system of fire safety in the form of a multilevel complex of universal modules including the developed concentrator is represented in Fig. 3. Here the concentrator represents information system which works both autonomously and integrated into a more branched system.

Such concentrator of a fire extinguishing system is intended for collecting, processing of signals from 16 various sensors and devices, and also for information transfer to remote devices (repeaters). It consists of an input device; processing and control devices, as well as an output device. The input device contains 16 discrete channels. It is intended for filtration of signals and protection of the equipment against influence of a high voltage. The processing and control device has the following functions:

1. Carries out the analysis and processing of input information (assignment of temporary delays for fixation of input operation and inverting of separate inputs).
2. Sets temporary delays for turning on of output devices, the light and sound alarm system.
3. Controls work of the main source of power supply and charging of a reserve source (battery).

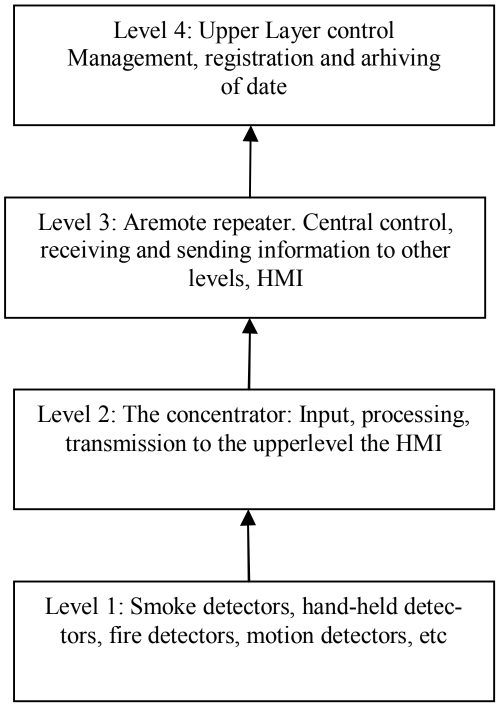

Figure 3 – Concentrator, as multilevel complex of universal modules transfer to remote devices (repeaters)

4. Carries out automatic restart of the governing microcontroller in the case of "lag" during operation under the conditions of industrial hindrances. Control scheme "Watchdog Timer" is applied to it. It is implemented in hardware and it is a timer that periodically resets the control system. If there was no reset for a predetermined time interval, the force reboot of the system occurs.
5. Collects data about the condition of other concentrators, in the case when the system consists of more than one device (up to four concentrators can work simultaneously).
6. Tests a self-diagnostics mode.
7. Provides information exchange with remote repeaters (up to four devices) through CAN-interface at the distance of up to 1 kilometer, when they are connected to the concentrator.
8. In case of loss of communication, turning off and later turning on of the main concentrators or remote repeaters, automatically restores data transmitted to a remote repeater.
9. Carries out an automatic configuration of concentrators after power supply. Each concentrator defines its location in system (if there are more than one) and is adjusted to the corresponding operating mode.

Fig. 4 illustrates a structure of the concentrator in information system where the concentrators are united in complex.

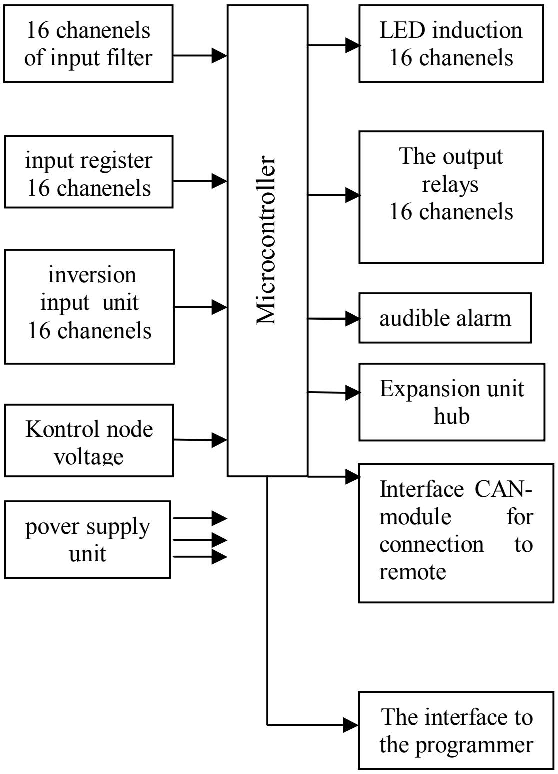

Figure 4 – Concentrator structure

In information system concentrators unite in complexes.

Fig. 5 represents the structure of the complex consisting of four concentrators and four remote repeaters.

It is possible to carry to distinctive features of this concentrator: universality, the expansibility, increased reliability and fault tolerance.

For example, if after switching concentrator identified themselves as "Master" (Fig. 5), it is to communicate with a remote repeater module activates at CAN-interface. At the same time activates the I2C-interface module for communication with expansion modules (concentrator mode "Slave"); To ensure the real- time mode , data exchange interfaces supported via interrupt (interrupt driven serial communication).

10. During operation the main concentrators (concentrators mode "Slave") convey information about the status of their sixteen inputs and information about the state of the power hub when they are in "Master" immediately once an event has occurred, such as changing the state of the inputs. Concentrator is in mode "Master", with a delay not exceeding one second transmit updated information to the remote concentrator. In the absence of receipt of the data concentrator periodically retransmits. After receiving data at a remote concentrator, the number of expansion modules for transmitting a signal to the remote repeater mode "Slave" is determined. For example, if at the main concentrator "Slave – 3" there was a change of state at the input number 5, then the appropriate indicator of remote repeater mode "Slave - 3" will display that state. To ensure complete reliability of data transmission, remote concentrator, located in the mode of "Master", after power-up or reset requests from the main concentrator data again.

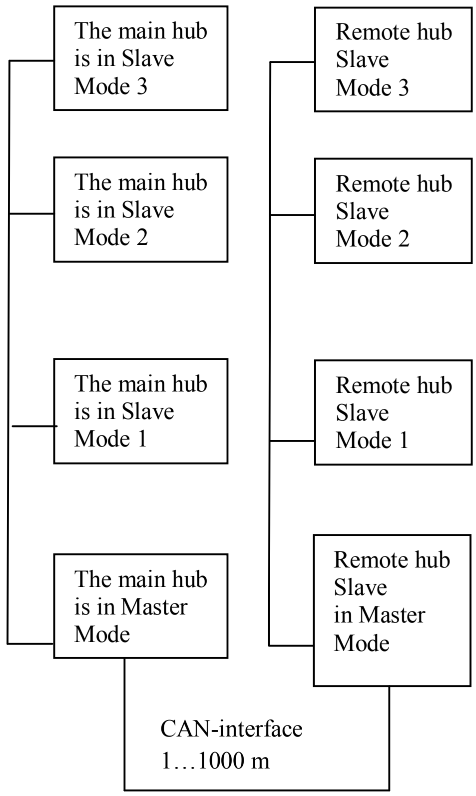

Figure 5 – Structure of the complex consisting of four concentrators and four remote repeaters

Remote and basic concentrators are connected via CAN-interface. The main concentrator contains a CAN module and a transceiver. Fig. 6 shows a schematic connection of the main and remote concentrators. The specific features of the developed concentrator include universality, expansibility, improved reliability and fault tolerance.

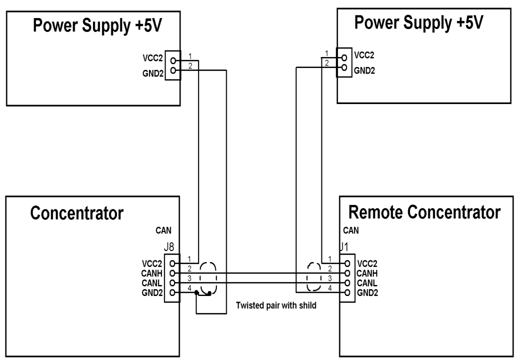

Figure 6 – Wiring plan of main and remote concentrators

Universality consists in the fact that the concentrator allows the operator to adjust and configure operation of the device for various types of input sensors and output executive devices. During the work in a complex with several additional concentrators each of them automatically defines its function at start and is configured. Expansibility consists in the possibility of parallel connection of both the main concentrators and remote repeaters to four units. Exchange of information between parallel modules is carried out on the I2C interface. Data exchange with remote repeaters is performed by the highly reliable noise proof field bus CAN.

CAN interface is created to provide a high level of data protection against damages during operation under difficult conditions. It is absent in the majority of conventional fire extinguishing systems.

It has data transmission speed up to 1 Mbit/s. It allows creation of fire alarm networks in real time.

Increased reliability and fault tolerance is caused by use of the modern high-performance PIC24F microcontroller of Microchip firm (USA); built-in system of self-testing; original circuit designs and effective software.

Let us consider the organization of information transfer from the bottom level sensors to the top level of the system and improved reliability of information transfer in detail.

The task of ensuring high reliability is met for both hardware and software. At the hardware level, the goal is achieved using a stand-alone transceiver ISO1050 interface CAN (Controller Area Network). The ISO1050 combines innovative CAN interface and isolation technology Texas Instruments, which helps to make the number of required components at least half as many and simplifies the design of circuit boards for industrial automation. Device ISO1050 reduces power consumption at the system level by 38 % in comparison with the solutions for opto-isolation.

The case 6,1 mm wide reduces the installation area on the plate by 30 %, which is extremely important for the high-voltage appendices requiring the minimum gap. In addition to it, ultralow level of the electromagnetic emission (EME) allows using the device in sensitive analog applications, for example, industrial sensors.

According to the logic of the organization of data exchange, CAN differs from traditional interfaces. The exchange organization is event focused. It means that as soon as a node receives a message about an event to be communicated to other nodes (taking into account the above described arbitration procedure), it begins to broadcast transfer of the message. Such procedure is carried out without program poll, interruptions and without the controller operating the exchange. As a result survivability of system increases: even being divided into two parts, it keeps viability of each of them. Thus both subsystems will be able to function independently. Another consequence of the equality of all components consists in saving time for delivery of the message to the recipient due to decentralization.

As it has already been mentioned, there is no notion of “address” in CAN but there is an idea of “identificator” which is, in fact, the address of the data-transfer register (in interface CAN nodes there are no receiving registers admissible through registry in accordance with the program). Every identificator is rigidly connected with the data array that can be transferred to the line when the transfer is initiated by the corresponding node. All the other nodes “hear” the line and analyze the identificators of the transferred messages receiving only their “own” data and ignoring all the others. The data can be received by several nodes simultaneously. It significantly enhances the interface operation due to the absence of doubling the transfer of the same data to different nodes.

Event focused logic of operation of the interface organically includes the procedure of data query. If a subsystem requires the data formed by another subsystem, it sends a message with a request for these data, specifying the identifier in it. In reply the subsystem that is the holder of the data transfers the corresponding message. The event which has caused the necessity for data, initiates their delivery.

Thus, CAN interface use in systems of safety allow:

1. To lower the load of the network since all messages transferred in the system, are event ones and are accepted at once by all devices of the system.
2. To provide the high speed of system reaction.
3. To define communication problems and failure of system devices, using message confirmation mode and self-diagnostics mode based on the clock impulse mechanism "on bus".
4. To keep operability of the system at a rupture of the communication line.
5. To connect and disconnect devices without change-over of other *knots* of the system.
6. To improve the reliability of the system because of the possibility of simplification of network architecture and reduction of number of backbone components.
7. To increase survivability of the safety system at the expense of reliable interaction of the system devices.
8. To achieve reduction of cost of object protection systems as a result of application of the simplified structure functioning without continuous presence of the control panel in the structure.

Flexibility of the distributed networks on the basis of the CAN bus allows to realize the technology of modular construction by a method of design configuration of systems.

The systems constructed on the basis of the CAN bus can optimally operate a big set of objects located in the distributed territory.

CONCLUSIONS. A fire extinguishing system concentrator representing a complex of the main and remote concentrators is developed. Information fire extinguishing system based on continual notion of fire emergence process is offered.

Concentrators are combined into complexes in the information system. This system allows to read out signals from sensors and to transfer them to the control panel at a considerable distance from the seat of fire. Operation of the existential transformation of information (ETI) is defined as an action in which scanning, measurement, information processing and delivery of operating signals are combined. It is shown how information transfer from bottom level sensors to top levels in the system is organized with high reliability. The problem of ensuring high reliability is solved both at hardware and software level. CAN -interface is created to provide a high level of data protection against damages during operation under difficult conditions. It is absent in the majority of conventional fire extinguishing systems. It has data transmission speed up to 1 Mbit/s. It allows creation of fire alarm networks in real time.

Used in fire extinguishing systems CAN-interface allows you to: reduce the load on the network, provide high-speed information transmission; identify failure of system devices, connect and disconnect devices without reconfiguring other knots in the system, improve the reliability and survivability of the system. This information system and concentrator as complexes universal modules allow reliable protection of a variety of physical objects against fire and other emergencies.

REFERENCES

1. Putilin, A.B. (2000), *Vvedenije v teoriju preobrazovanija i obrabotki signalov* [Introduction to transform theory and signal processing], Kwadrat-C, Moskow, Russia.

2. Putilin, A.B, (2005), *Kontinualnije sistemi obrabotki informaciji* [Continuous data processing systems], Kwadrat-C, Moskow, Russia.

3. Arthur, E. Cote (2003), *NFPA Operation Of Fire Protection Systems*, Jones & Bartlett Learning.

4. Bryan, John L. (1982), *Fire suppression and detection systems*, Macmillan.

5. Boothroyd, Ted (2005), *Fire Detection and Suppression Systems*, Intl Fire Service Training Assn.

6. Craig, R. (2002), *Schroll, Industrial Fire Protection Handbook*, 2nd ed., CRC Press.

7. John, E. (1996), *Traister Fire Alarm Systems: Design, Installation, Maintenance*, McGraw-Hill School Education Group.

8. Delton, T. Horn (1995), E*lectronic Alarm and Security Systems*, TAB Books.

9. William, H. (1999), *Trimmer, Understanding and Servicing Alarm Systems*, Butterworth-Heinemann.

10. Richard Bukowski, Robert J. O'Laughlin (1994), *Fire Alarm Signaling Systems*, National Fire Protection Association.

11. Putilin, A.B., Polytron, V.E. (1980), *Ispolzovanije v shemah preobrazovanija informaciji* [Using a data conversion schemes], Energija, Moskow, Russia.

12. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein (2006), *Vvedenije v algoritmi* [Introduction to algorithms], Viljams, Moskow, Russia.

КОНЦЕНТРАТОР ИНФОРМАЦИОННОЙ СИСТЕМЫ ПОЖАРОТУШЕНИЯ

В. П. Ляшенко, М. В. Загирняк, А. С. Зиновьев, Ю. И. Соловьев

Кременчугский национальный университет имени Михаила Остроградского

ул. Первомайская, 20, г. Кременчуг, 39600, Украина. E-mail : Conon-v@yandex.ru

Ossokine Guennadi

Firm NEUTRONIC, France. E-mail: ossokine@yandex.ru

Разработан концентратор системы пожаротушения, состоящий из основных и отдаленных концентраторов. Информация с датчиков через систему основных и удаленных концентраторов передается информационной системе пожаротушения. В ее основу положены континуальные представления о процессе возникновения пожара. Через систему основных и отдаленных концентраторов информация с датчиков обрабатывается и передается на пульт управления, который расположен на значительном расстоянии от очага пожара. Операция пространственно-временного преобразования информации определена как действие, в котором совмещено сканирование, измерение, обработка информации и выдача управляющих сигналов. Для обеспечения высокого уровня защиты информации от поражения во время работы в сложных условиях и вести оповещение о пожаре в реальном масштабе времени создан CAN-интерфейс.

Ключевые слова: информационная система, концентратор, CAN-интерфейс.

Стаття надійшла 28.03.2014.